PASSIVE HOUSES IN NEW ZEALAND:
a comparison between predicted and real performance through post-occupancy evaluation

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RESEARCH PROCESS

Master of Architecture in Sustainable Design

Overview of NZ housing stock performance

Analysis of existing building certification schemes in NZ

Overview of Passive House worldwide & in NZ

Analysis of all certified Passive Houses in NZ

Post-occupancy evaluation of two completed Passive Houses

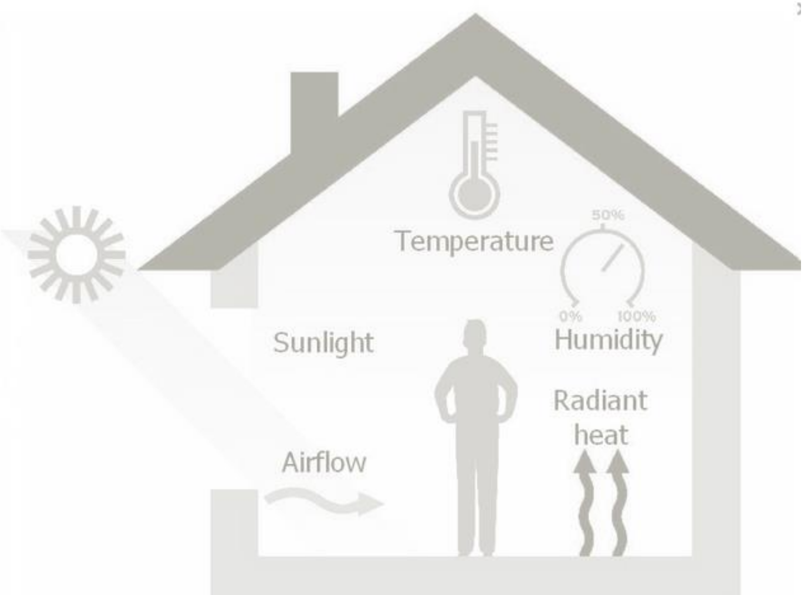
Quantitative Assessment

Qualitative Assessment

Comparison with NZBC code-complying houses

Conclusions, finding gaps and improvements for the future

Post Occupancy Evaluation (POE)



"The process of evaluating buildings in a systematic and rigorous manner **after** they have been built and occupied for some time. POEs focus on **building occupants and their needs**, and thus they provide insights into the consequences of past design decisions and the resulting building performance. This knowledge forms a sound basis for **creating better buildings in the future**"

Preiser, Rabinowitz, & White, 1988

Auckland

Whanganui

Auckland

Completed in 2014

Construction: Timber framing with double layer of insulation

8kW Photovoltaic Panels

Passive House certification:
In progress

Homestar: 8/10 rating granted

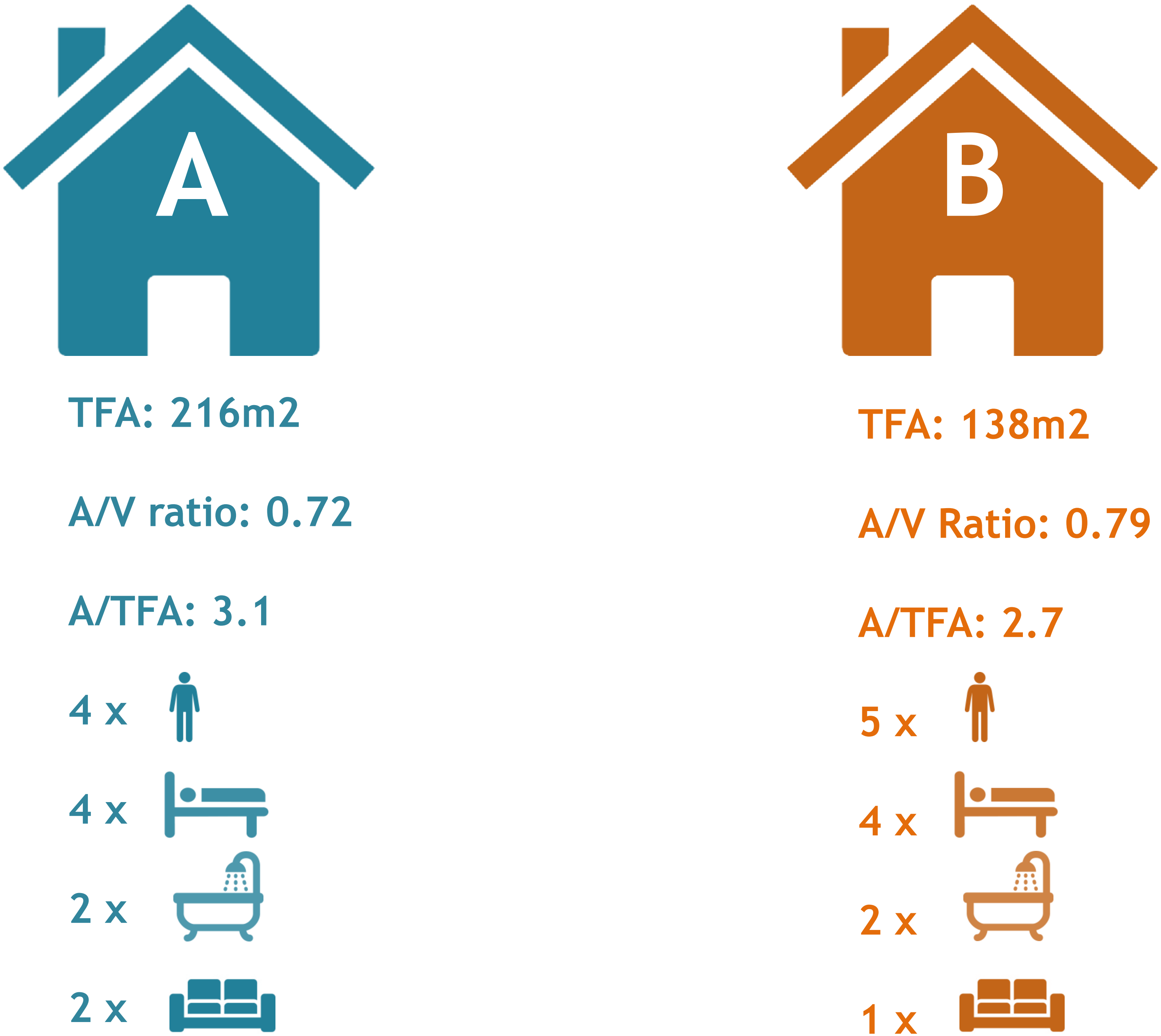
Whanganui

Completed in 2014

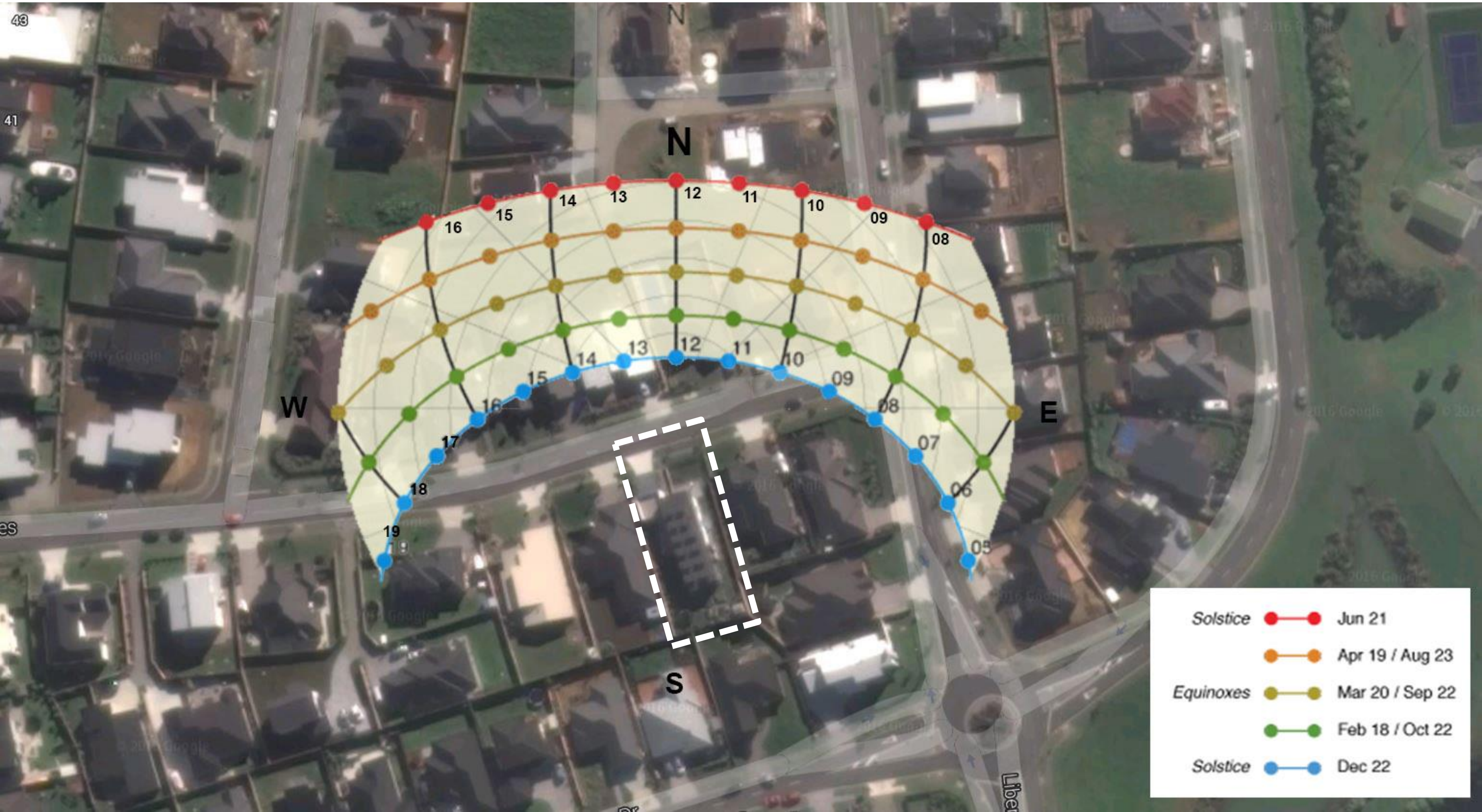
Construction: Insulated Concrete Forms (ICF)

3kW Photovoltaic Panels

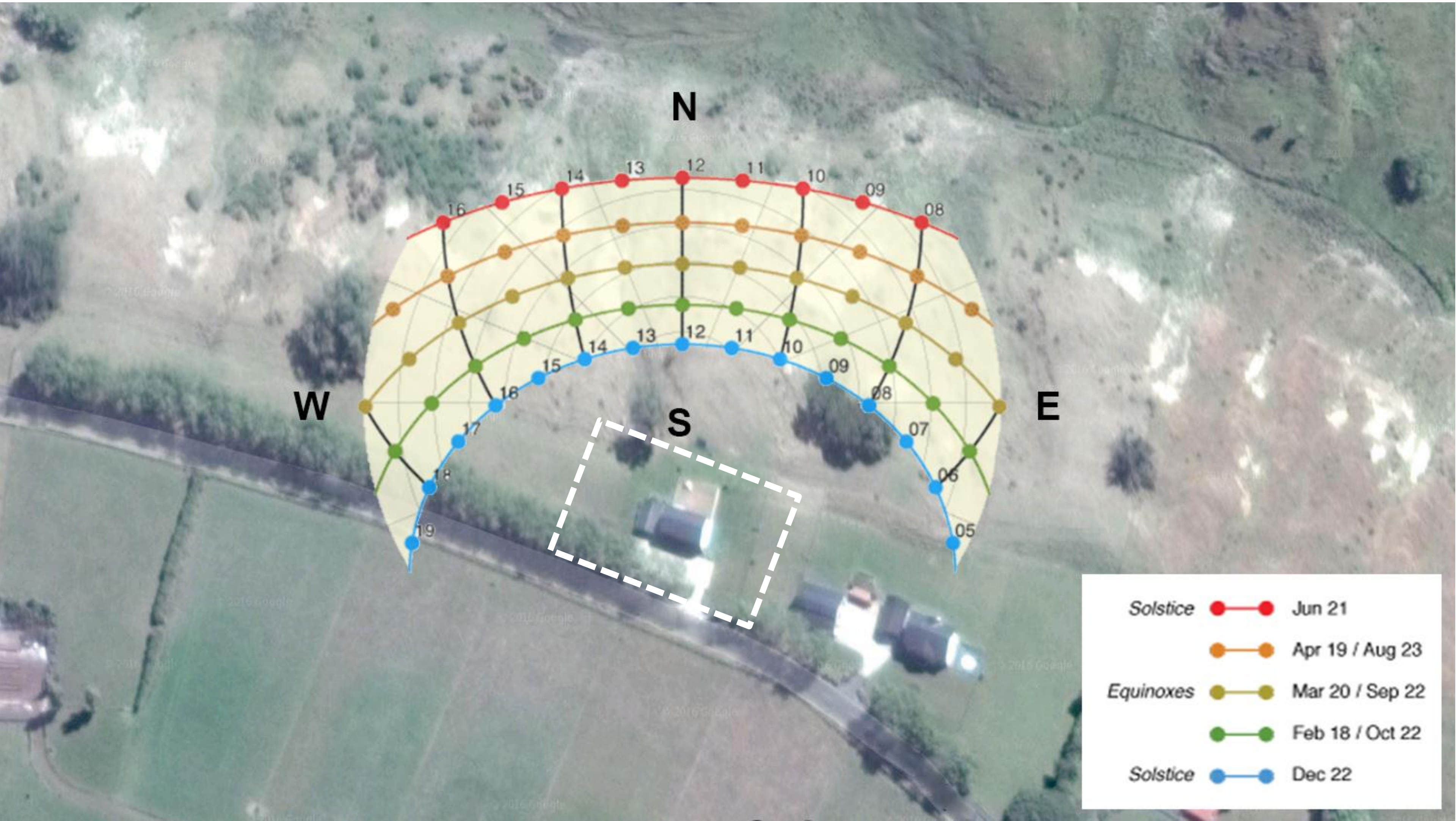
Passive House certification:
Granted

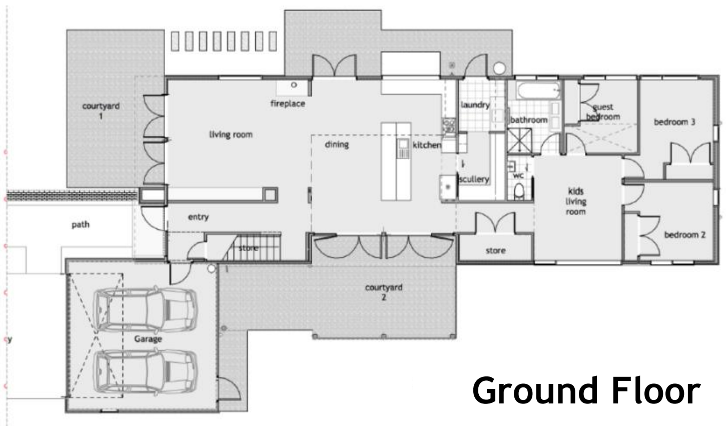

A
TFA: 216m2
A/V ratio: 0.72
A/TFA: 3.1
4 x
4 x
2 x
2 x
B
TFA: 138m2
A/V Ratio: 0.79
A/TFA: 2.7
5 x
4 x
2 x
1 x

Orientation

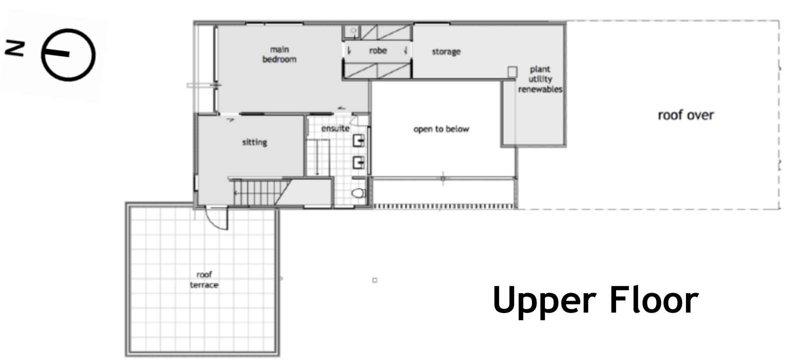


Orientation

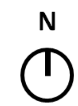


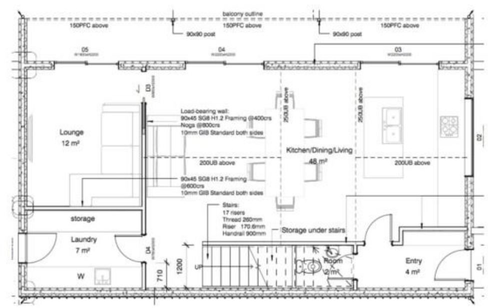


Ground Floor

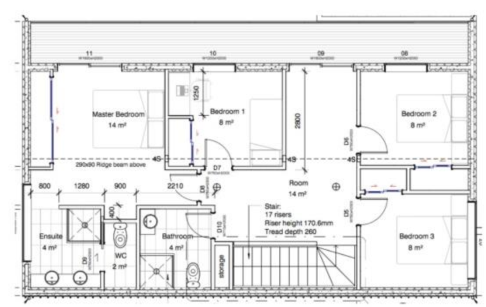


Upper Floor





Ground Floor



Upper Floor

Comparison: Insulation

Component	House A		House B		NZBC Minimum
	U-Value W/(m²K)	R-Value (m²K)/W	U-Value W/(m²K)	R-Value (m²K)/W	R-Value (m²K)/W
Floor Slab	0.433	2.309	0.240	4.167	1.3
Walls	0.282	3.546	0.261	3.831	1.9
Roof	0.183	5.464	0.145	6.896	2.9
Glazing - Uw	0.900	1.11	1.870	0.535	0.26
Glazing - Ug	0.690	1.449	1.100	0.909	

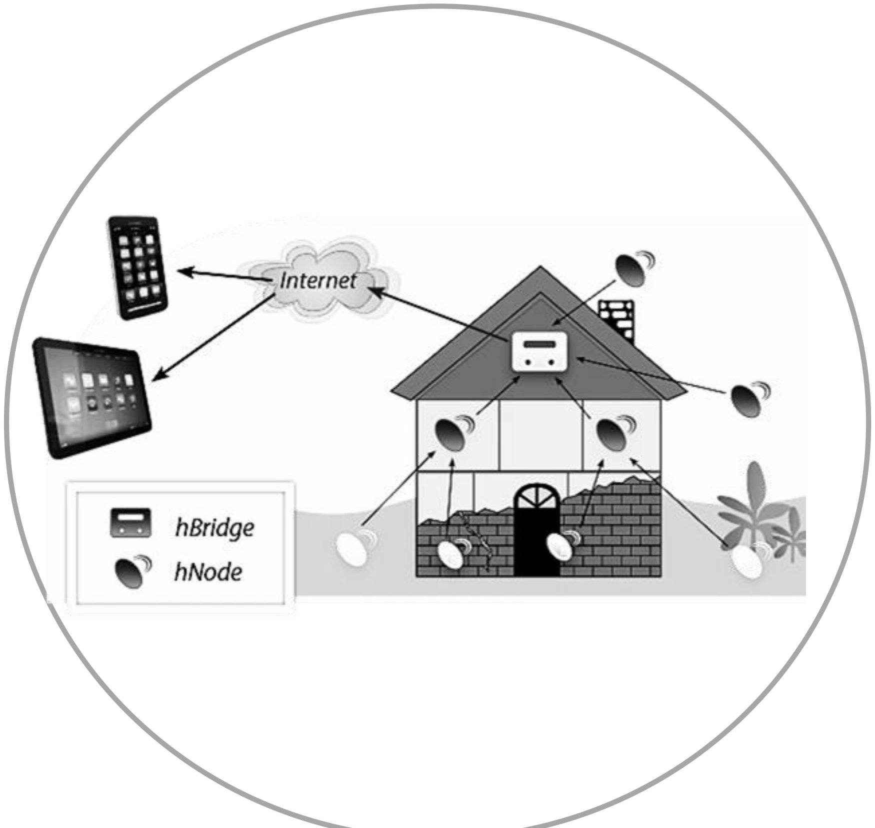
Comparison: Window-to-wall Ratio

Façade	Value	House A (Auckland)	House B (Whanganui)
North	Window Area	$23m^2$	$26m^2$
	Window-to-wall ratio	45%	39%
South	Window Area	$3m^2$	$0m^2$ *
	Window-to-wall ratio	9%	0% *
East	Window Area	$20m^2$	$3.2\ m^2$
	Window-to-wall ratio	16%	8%
West	Window Area	$36m^2$	$2.5m^2$
	Window-to-wall ratio	31%	6%

*There are no windows in the South façade of House B.

Quantitative Data

Monitoring System



Sensors installed in different rooms+
Data transmission bridge

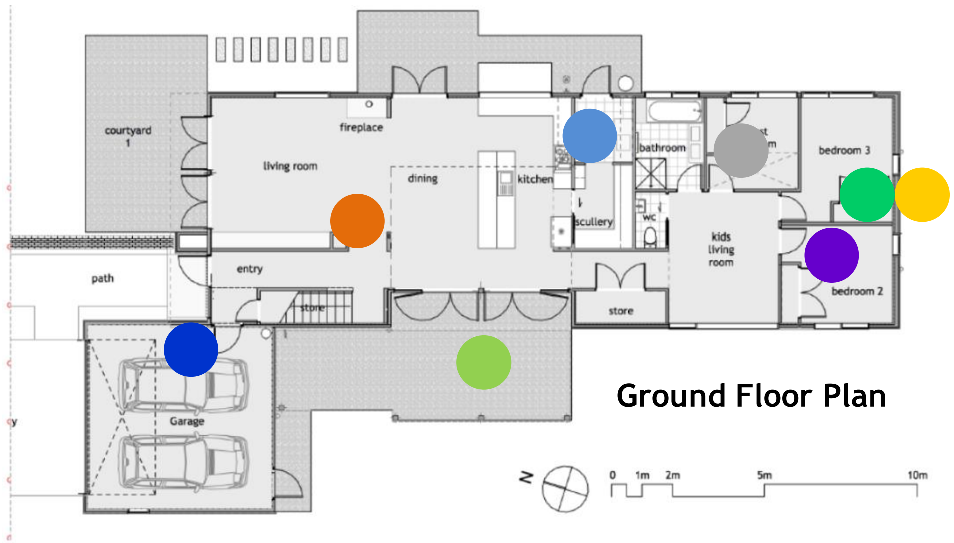
Data:

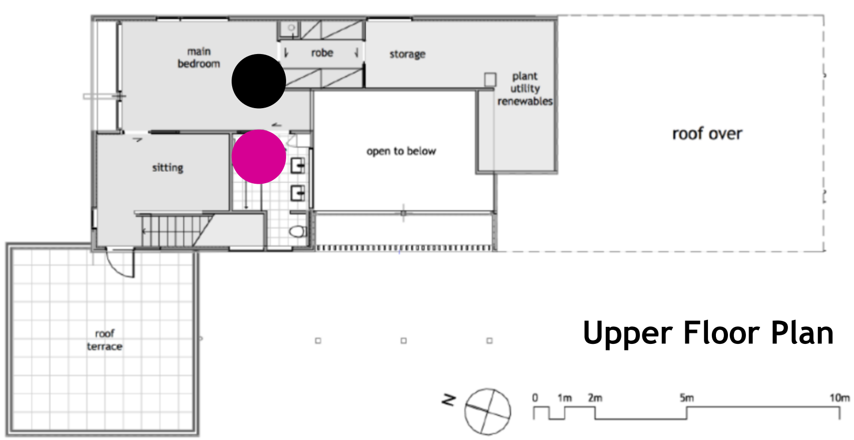
Ambient temperature
Relative humidity
Wall heat flow
CO_2 concentration
Luminance
Energy consumption and production

- Data gathered every 15 minutes
- Available online for homeowners and researchers

- Measurement procedures according to ISO 7726 (1998)
- All sensors positioned away from windows to avoid direct sunlight

Quantitative Data



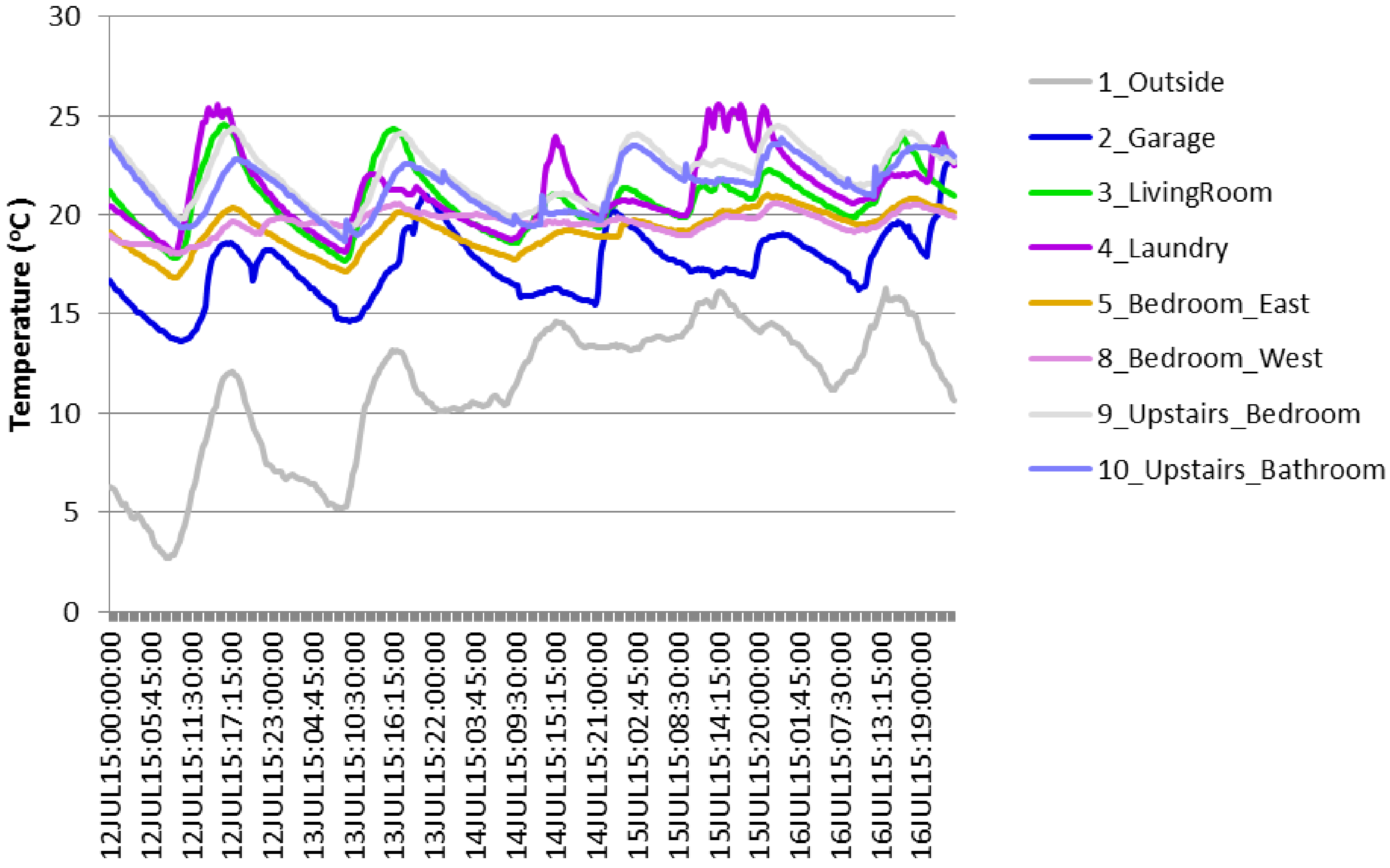


Position of sensors

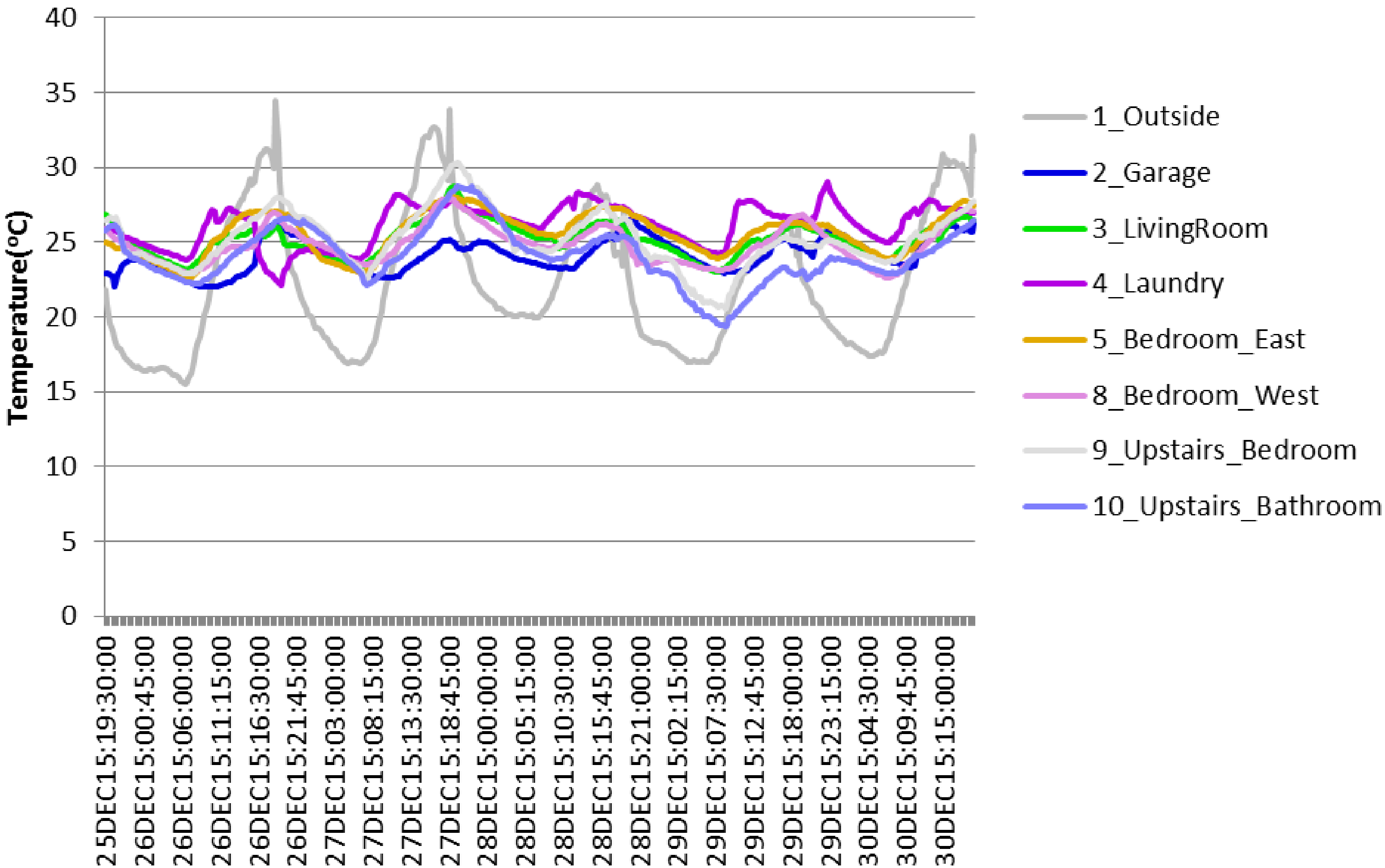
- 1 Outside
- 2 Garage
- 3 Living Room
- 4 Laundry – Air Exhaust
- 5 Bedroom East – Air Supply
- 6 Guest Bedroom
- 7 Guest Bedroom
- 8 Bedroom West
- 9 Upstairs Bedroom
- 10 Upstairs Bathroom

Monitoring System

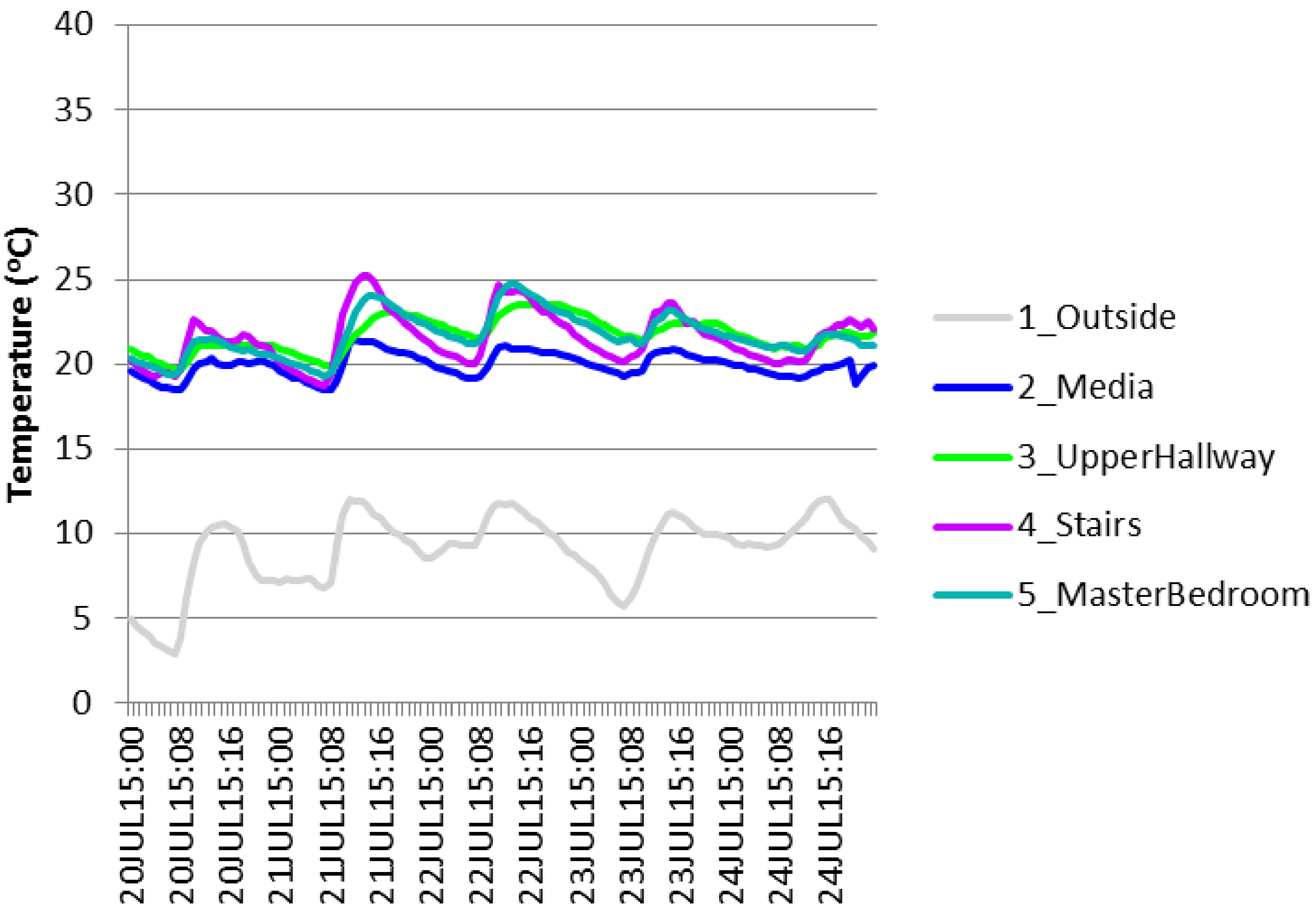
Winter Peak Temperature



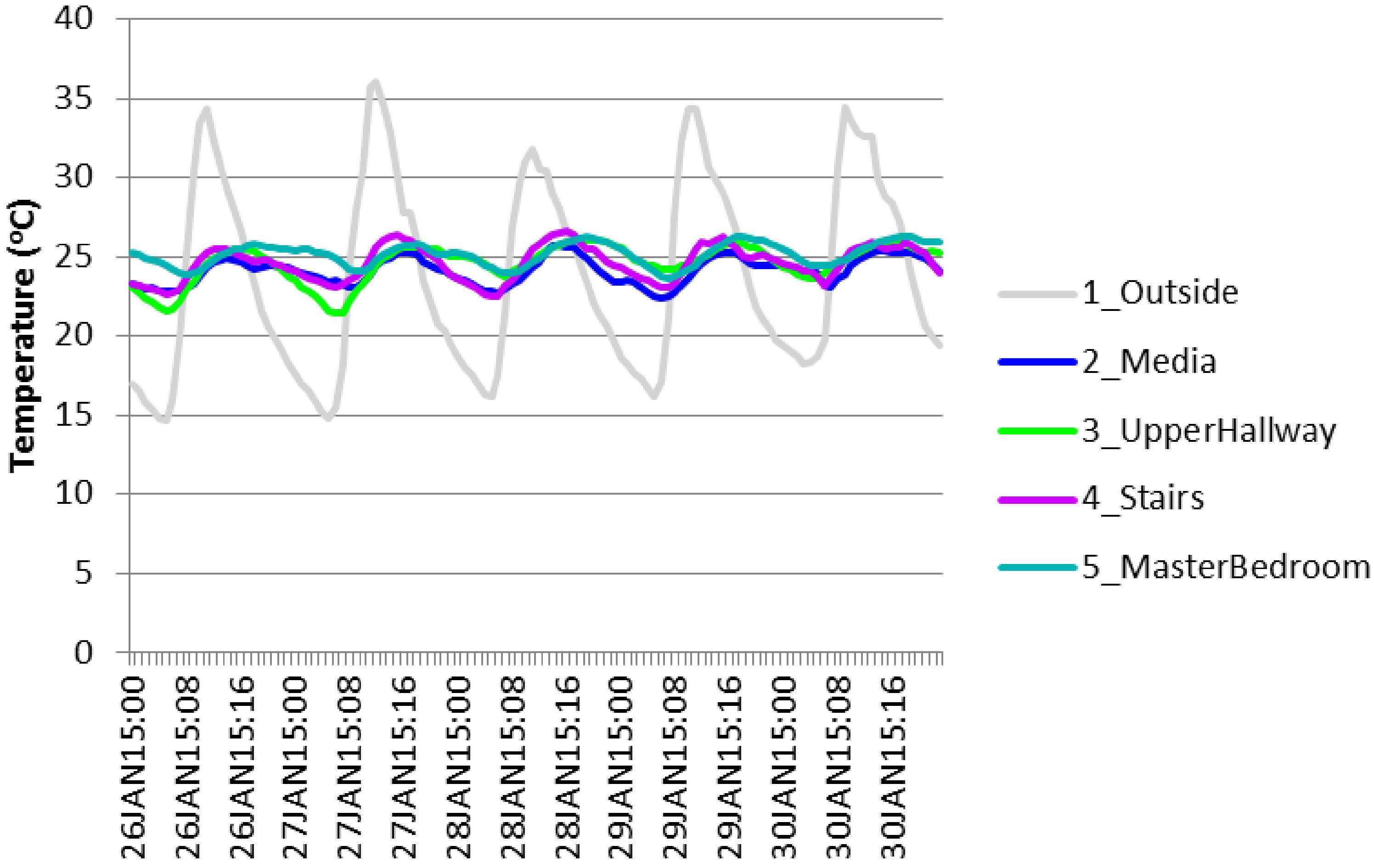
Summer Peak Temperature



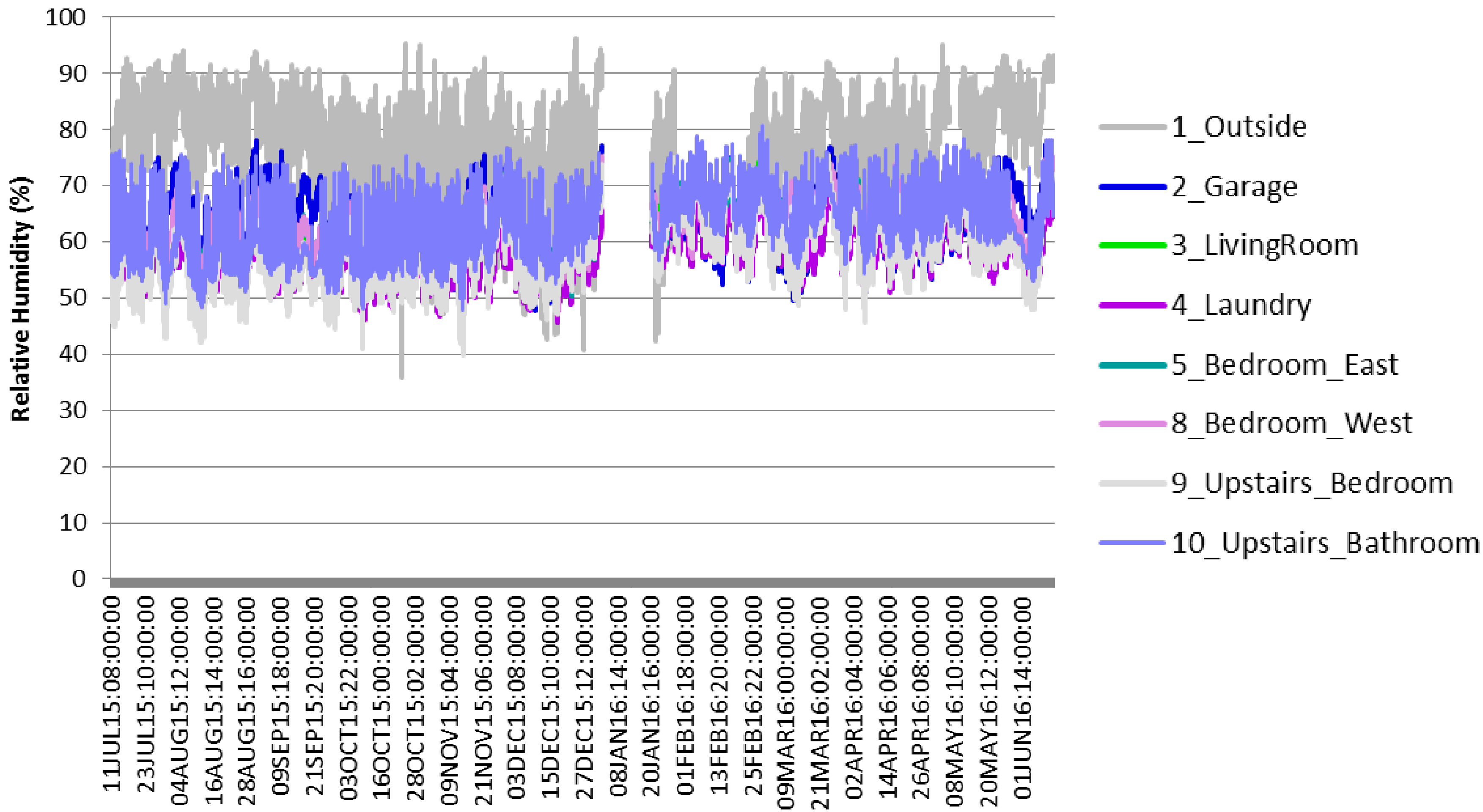
Winter Peak Temperature



Summer Peak Temperature



Humidity - full period



Qualitative Assessment

Interviews based on ISO 7730

Thermal sensation assessed retrospectively

Occupant #1	Occupant #2
Gender: Male Age: 30-40	Gender: Female Age: 30-40
Thermal Comfort	
How would you evaluate the overall environmental comfort experienced in the building? In a scale where -3 is cold, 0 is neutral/comfortable and +3 is hot, how would you rate the house overall?	
0	0
How would you evaluate the indoor thermal comfort of the house in winter? In a scale where -3 is cold, 0 is neutral/comfortable and +3 is hot, how would you rate the house in winter? What is the coldest part of the house in winter?	
It's comfortable, so I would say 0. Coldest parts of the house are the two southern bedrooms, just a fraction colder than the rest of the house	Between -1 and 0 Coldest part is the back of the house – the two bedrooms facing South, they don't get as much thermal gains, no direct sun
How many layers of clothing do you usually have to wear at home in winter?	
One: just pants and T-shirts	Usually one
How would you evaluate the indoor thermal comfort of the house in summer? In a scale where -3 is cold, 0 is neutral/comfortable and +3 is hot, how would you rate the house in summer? What is the warmest part of the house in summer?	
+1 The warmest room of the house used to be the TV room upstairs. But we had the windows tinted, which made a huge difference. So, now the warmest room is probably the master bedroom. The living room does not feel warmer than the rest of the house – it has a high ceiling, so the heat moves up.	From 0 to +1
How would you describe moisture in the house – especially kitchen and bathroom areas?	
No at all. As indicated in the measurements	No issue with moisture, we don't have any

Qualitative Assessment

Key findings:

Occupants felt comfortable in all seasons

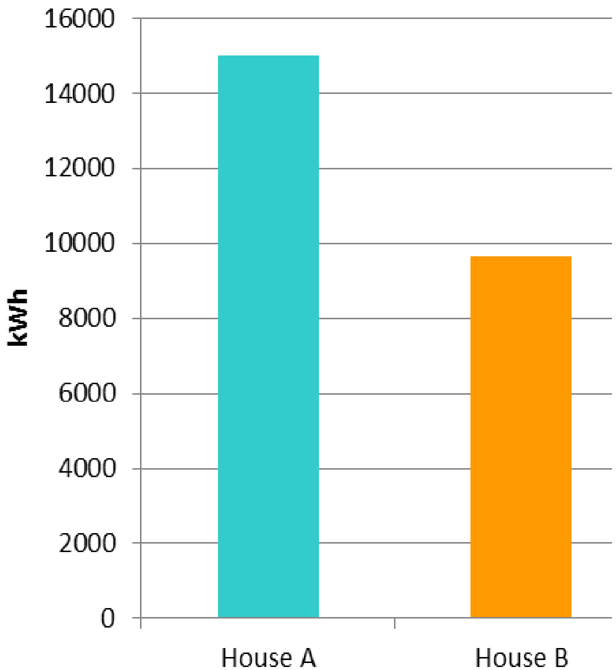
Health benefits – especially for children

Superior indoor environment compared to their workplaces, previous houses and other buildings

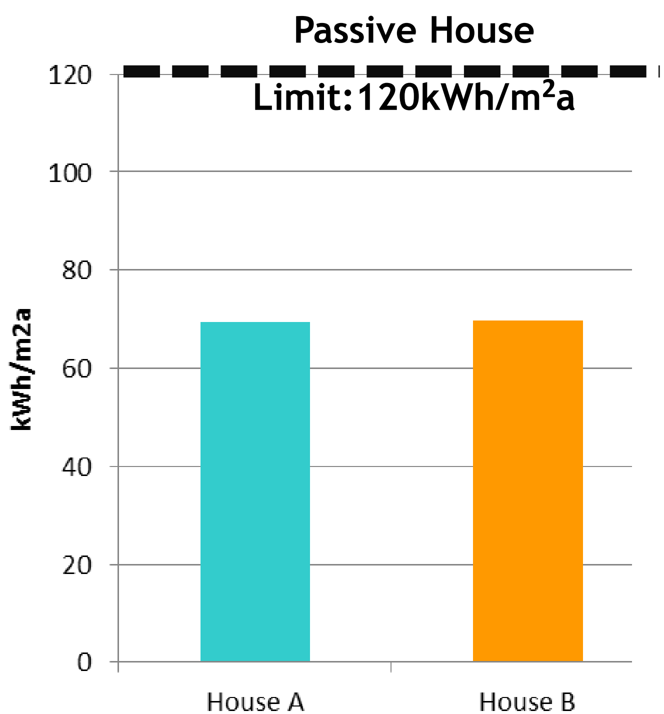
Occupants would like to have additional shading in summer

Energy consumption and production

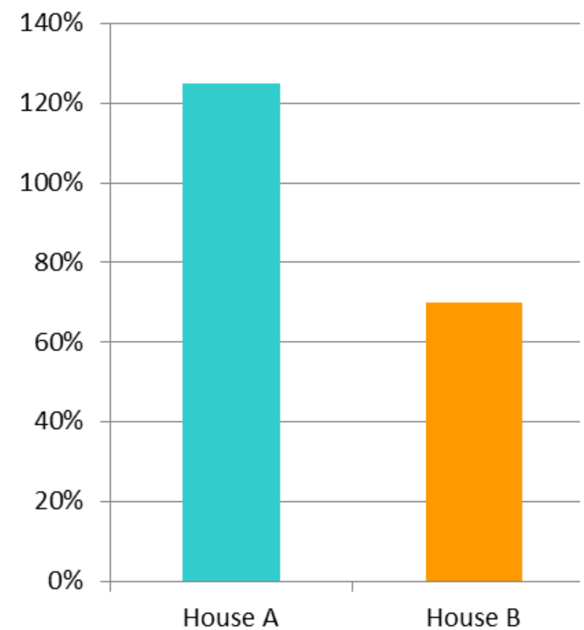
Annual Primary Energy Demand (total)



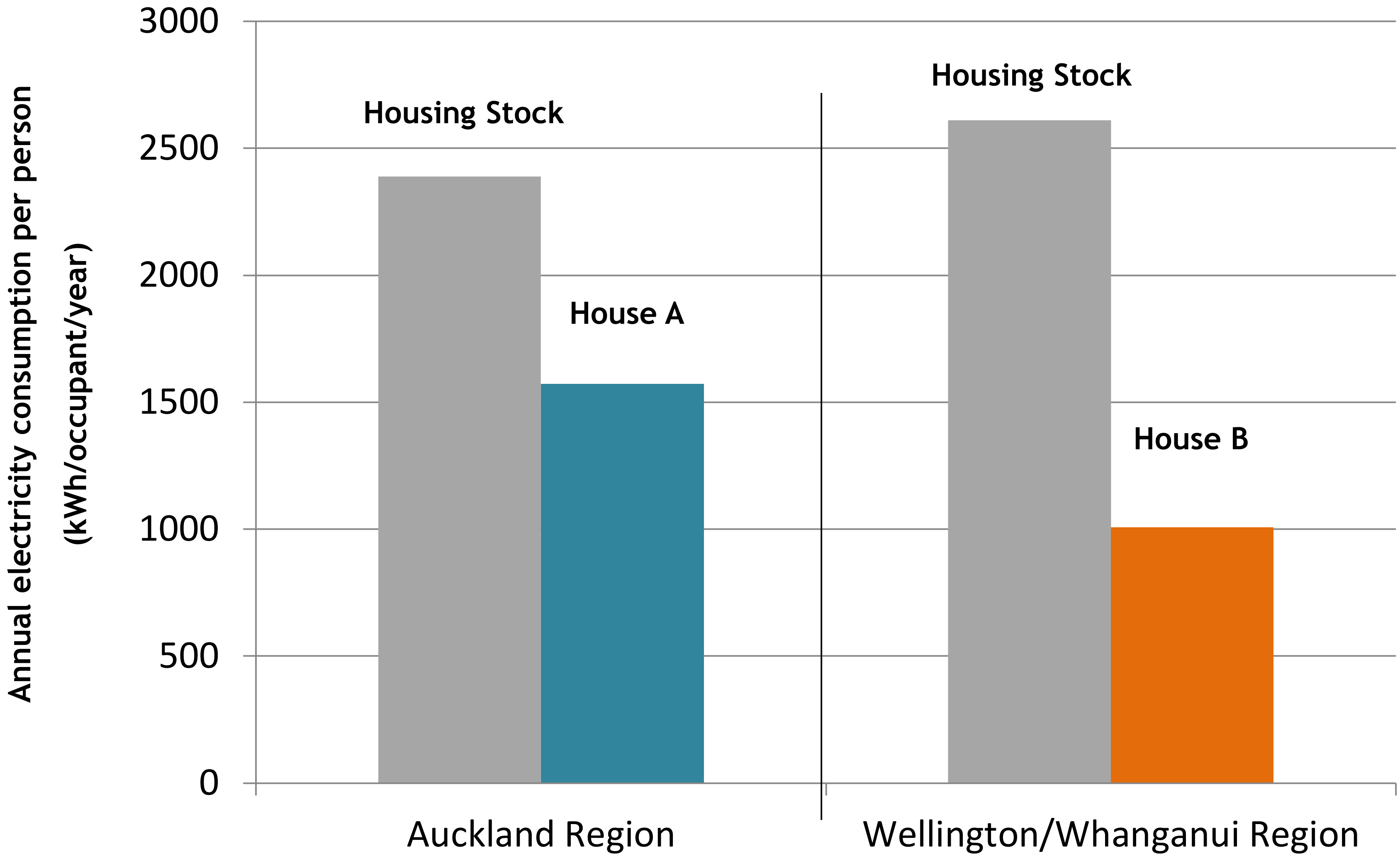
Annual Primary Energy Demand per square metre



Percentage of energy provided by solar panels



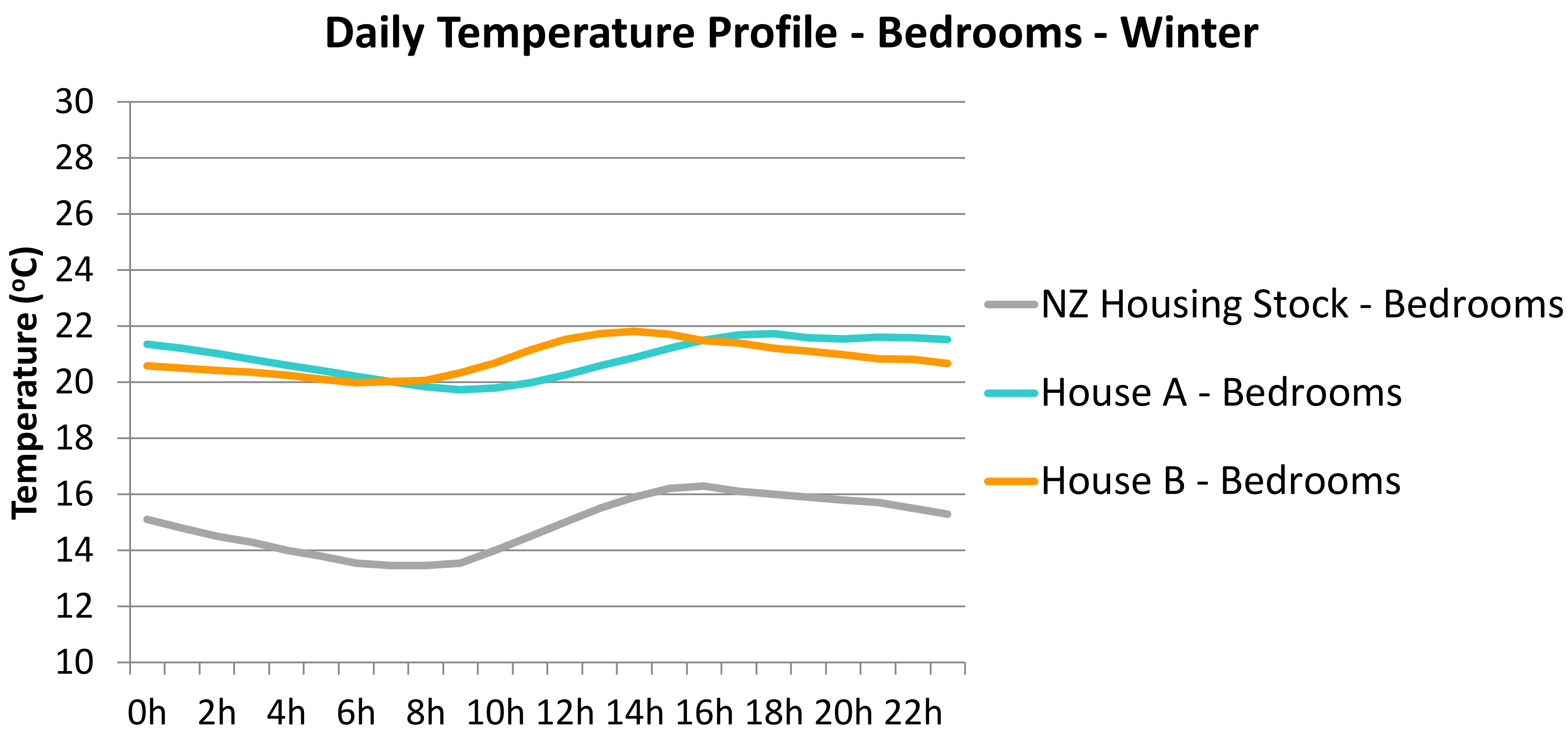
Comparison: Energy consumption



Housing stock energy consumption from HEEP (BRANZ): http://www.branz.co.nz/HEEP-energy-graphs/graphs.aspx

Comparison: Temperature

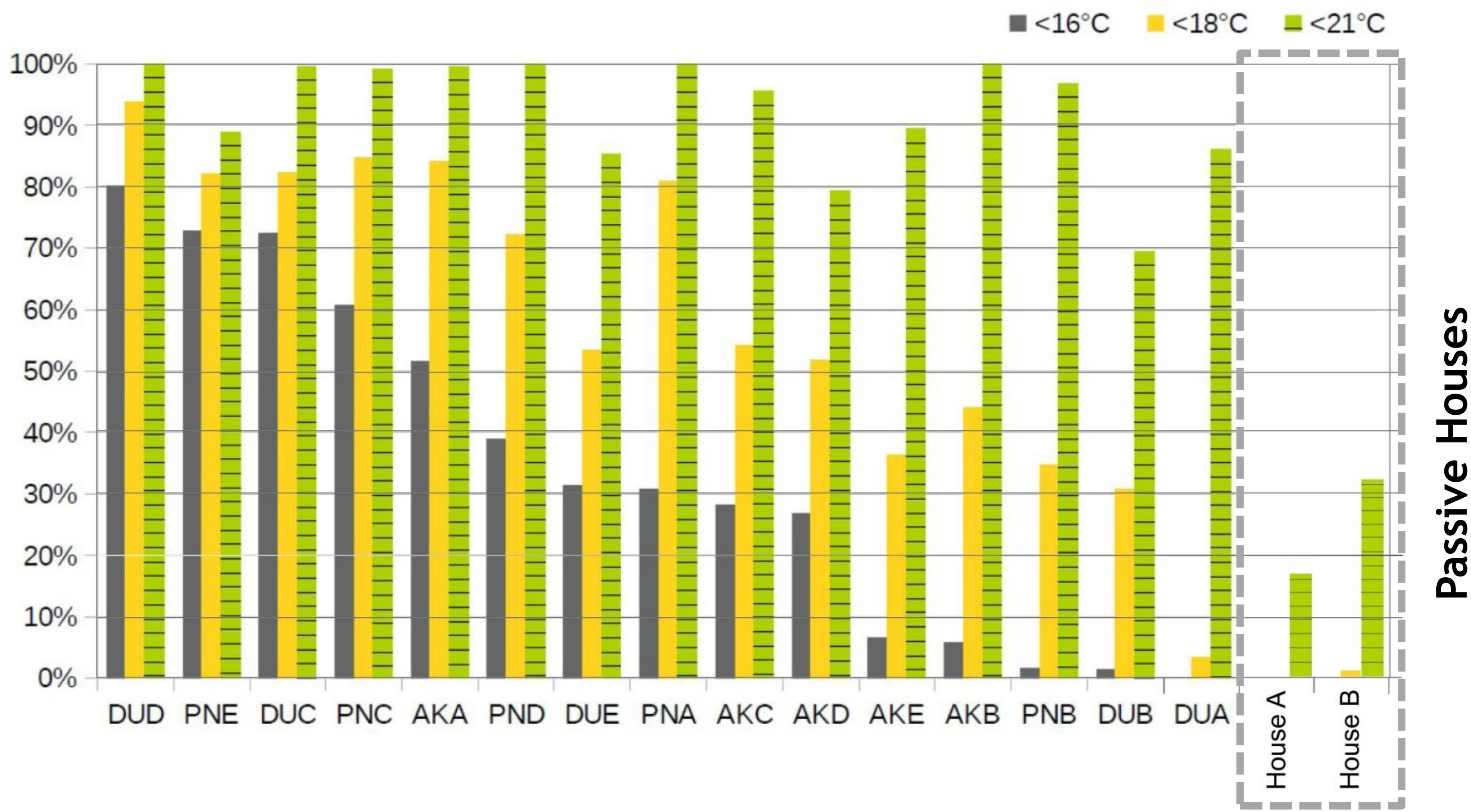
Comparison with New Zealand dwellings built after 1978



Housing stock temperatures from HEEP (BRANZ): http://www.branz.co.nz/HEEP-energy-graphs/graphs.aspx

Comparison: Temperature

Comparison with New Zealand code-compliant houses built after the year 2000



Time-weighted temperature ranges for living rooms: Comparison between 15 code-compliant houses (left) and two Passive Houses (right). Based on Rosemeier (2014): Healthy and affordable housing in New Zealand: the role of ventilation.

CONCLUSIONS

Real performance is very similar to simulation predicitions;

Design choices and occupants' behaviour have significant impact on performance;

Passive House performance is confirmed to be **highly superior in terms of energy and comfort when compared to housing stock**;

There is still scope for improving design and technical solutions;

Health benefits are evident;

Sun shading is key for achieving comfortable conditions indoors during summer;

Next challenges are no longer to confirm that Passive Houses work well, but to investigate how to increase the number of houses built this way.

FUTURE RESEARCH FOR PH IN NZ

Group builders

Prefabrication

Retrofitting existing housing stock

Affordability

Multi unit Passive Houses

Life cycle assessment

Thank You!

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